Developing a Transmission-Efficient Clustering Method for Wireless Sensor Networks Using Hybrid Compressive Sensing

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Abstract—Compressive sensing (CS) can reduce the number of data transmissions and balance the traffic load throughout networks. However, the total number of transmissions for data collection by using pure CS is still large. The hybrid method of using CS was proposed to reduce the number of transmissions in sensor networks. However, the previous works use the CS method on routing trees. In this paper, we propose a clustering method that uses hybrid CS for sensor networks. The sensor nodes are organized into clusters. Within a cluster, nodes transmit data to cluster head (CH) without using CS. CHs use CS to transmit data to sink. We first propose an analytical model that studies the relationship between the size of clusters and number of transmissions in the hybrid CS method, aiming at finding the optimal size of clusters that can lead to minimum number of transmissions. Then, we propose a centralized clustering algorithm based on the results obtained from the analytical model. Finally, we present a distributed implementation of the clustering method. Extensive simulations confirm that our method can reduce the number of transmissions significantly.

Index Terms: Wireless sensor networks, compressive sensing, data collection, clustering.

INTRODUCTION

IN many sensor network applications, such as environment monitoring systems, sensor nodes need to collect data periodically and transmit them to the data sink through multihops. According to field experiments, data communication contributes majority of energy consumption of sensor nodes. It has become an important issue to reduce the amount of data transmissions in sensor networks. The emerging technology of compressive sensing opens new frontiers for data collection in sensor networks and target localization in sensor networks. This method can substantially reduce the amount of data transmissions and balance the traffic load throughout the entire network. The basic idea of CS works is as follows, as shown in Fig. 1. Suppose the system consists of one sink node and N sensor nodes for collecting data from the field. Let x denote a vector of original data collected from sensors. Vector x has N elements, one for each sensor. x can be represented by _s, i.e., x ¼ _s, where _ is an N _ N transform basis, and s is a vector of coefficients. If there are at most k (k _ N) nonzero elements in s, x is called k-sparse in the domain. When k is small, instead of transmitting N data to the sink, we can send a small number of projections of x to the sink, that is, y ¼ _x, where _ is an M _ N (M _ N) random matrix (and y is a vector of M projections.

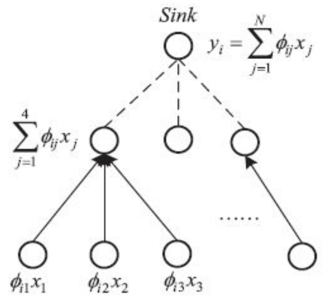

Fig.1 Data collection with the pure CS method in the tree structure

By using CS in data gathering, every node needs to transmit M packets for a set of N data items. That is, the number of transmissions for collecting data from N nodes is MN, which is still a large number. Hybrid approaches to overcome these problems. In the hybrid method, the nodes close to the leaf nodes transmit the original data without using the CS method, but the nodes close to the sink transmit data to sink by the CS technique. The previous works use the CS method on routing trees. Since the clustering method has many advantages over the tree method, such as fault tolerance and traffic load balancing, we use the CS method on the clustering in sensor networks. The clustering method generally has better traffic load balancing than the tree data gathering method. This is because the number of nodes in clusters can be balanced when we divide clusters. In addition, the previous works ignored the geographic locations and node distribution of the sensor nodes. In this paper, we propose a clustering method that uses the hybrid CS for sensor networks. Within a cluster, nodes transmit data to the cluster head (CH) without using CS. A data gathering tree spanning all CHs is constructed to transmit data to the sink by using the CS method. In this regard, we first propose an analytical model that studies the relationship between the size of clusters and number of transmissions in the hybrid CS method, aiming at finding the optimal size of clusters that can lead to minimum number of transmissions. Then, we propose a centralized clustering algorithm based on the results obtained from the analytical model. Finally, we present a distributed implementation of the clustering method.

LITERATURE SURVEY

2.1 Efficient Measurement Generation and Pervasive Sparsity for Compressive Data Gathering

Applied CS theory to wireless sensor networks to address the large-scale data gathering problem. Simulation results based on real sensor data have demonstrated the efficiency of CDG in exploiting the pervasive Sparsity .Main challenges of this concept are how to efficiently collect measurements &how to recover data from the least number of measurements. CDG is more suitable for large scale sensor networks. CDG is also effective for networks with stable routing structure. The extension of CDG is more challenging networking scenarios.

2.2 An Introduction to Compressive Sensing.

Cs theory asserts that one can recover certain signals and images from far fewer samples or measurements than traditional methods use. Compressed sensing provides a fundamentally new approach to data acquisition which overcomes the common wisdom .CS is a very simple and efficient signal acquisition protocol which samples signals in a signal independent fashion at a low rate and later uses computational power for reconstruction from what appears to be an incomplete set of measurements.

2.3 Compressive sensing.

User can recover certain signals and images from far fewer samples or measurements than traditional methods use. CS operates very differently; it is possible to directly acquire just the important information about the object of interest.

2.4 Compressed Sensing for Network Data.

Reconstruct sparse or compressible networked data in a variety of practical settings, including general multihops networks and wireless sensor networks.

CS observations can be "data mined" for events of interest. Main focus is on managing resources during the encoding process. The decoding step also poses a significant challenge. The study of efficient decoding algorithms remains at the forefront of current research.

2.5 An Application-Specific Protocol Architecture for Wireless Micro sensor Network.

Low -energy adaptive clustering hierarchy (LEACH), protocol is praposed in this paper. It contains ideas of energy-efficient cluster-based routing and media access together with application-specific data aggregation. It achieves good performance in terms of system lifetime, latency, and application-perceived quality. Results show that LEACH can improve system lifetime by an order of magnitude compared with general-purpose multihops approaches. It is not cost-effective. Protocols are quite difficult to work, experience hands should work out.

WORKING OF HYBRID COMPRESSIVE SENSING

We first make the following assumptions:

1] The sensor nodes are uniformly and independently distributed in a sensor field. Such a deployment can be modelled as a Poisson point process.

2] All sensor nodes have the same fixed transmission power and transmission rate.

3] The location information is used in the distributed implementation

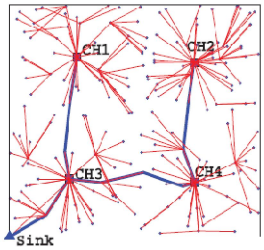

Fig 2. The hybrid CS data collection method in cluster structure.

4] Each sensor node is aware of its own geographic location, which can be obtained via attached GPS or Some other sensor localization techniques.

Sensor nodes are organized into clusters, and each cluster has a cluster head, represented by the solid square as shown in Fig. 2. Sensor nodes in each cluster transmit their original data to the CH without using CS. We assume each CH knows the projection vectors of all nodes within its cluster. In real systems, the measurement coefficient _ij can be generated using a pseudorandom number generator seeded with the identifier of the node vj Thus, given the identifiers of the nodes in the network, the measurement matrix can be easily constructed at CHs or the sink locally. The projections of all data in the network on the measurement matrix are the sum of the projections generated from the clusters. Thus in each round, the CH aggregate its own projection and the projections received from its children CHs in the same round and forwards it to the sink following the backbone tree.

MINIMUM TRANSMISSION CLUSTERING ALGORITHM

4.1 Overview of Centralized Clustering Algorithm

Data collected from sensor nodes is compressed by the CS method at the CHs. The data projections generated at each CH are forwarded to the sink in M rounds along the backbone tree. At each CH in the backbone tree, it aggregates its own data projection with the projections received from other CHs by using the CS method and forwards the aggregated projection upward toward the sink along the tree. There are usually multihops between two CHs. Thus, the problem of constructing a backbone tree that connects all CHs to the sink and has the minimum number of links in the tree is the well-known minimum Steiner tree problem, which is NP-hard. We will use an efficient heuristic method to construct the backbone tree.

4.2 Centralized Clustering Algorithm

Algorithm starts from an initial set of CHs, which is randomly selected. At each iteration, the algorithm proceeds following

Steps:

1. Connect sensor nodes to their closest CHs. Ties break arbitrarily.

2. For each cluster, choose a new CH, such that the sum of the distances from all nodes in this cluster to the new CH is minimized.

3. Repeat the above two steps until there is no more change of the CHs.

We use a minimum spanning tree (MST) based method to compute the backbone tree that connects all CHs and the sink.

DESIGN

The design of the project consists of the following

5.1 Data Flow Diagram

The dataflow diagram shows the flow of data between the system functions and process between users. It gives all information about flow of data between service provider, router and end user.

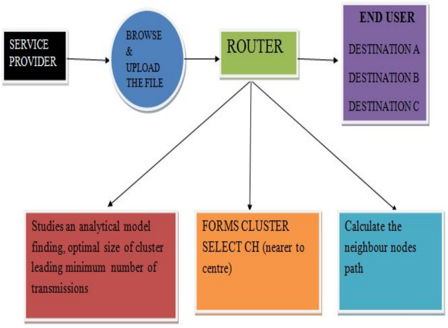

Fig: Data flow diagram

5.2 Use case Diagram

It is a type of behavioural diagram defined and created from a Use-case analysis. Its purpose is to present a graphical overview of the functionalities provided by a system in terms of actors and their goals. The main purpose of use case diagram is to show what system functions are performed for which actors.

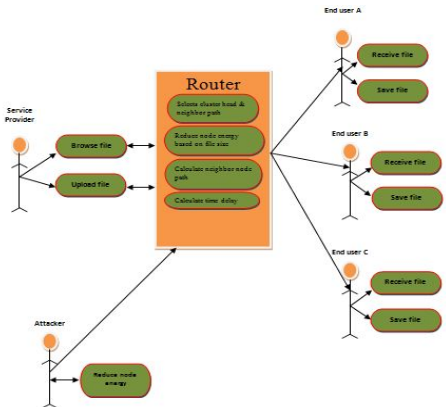

Fig: Use case diagram

5.3 Class Diagram

The class diagram represents the main objects interactions in the main objects, interactions in the applications and the class to be programmed. In the design of a system a number of class identified and grouped together in a class diagram which helps to determine the static relations between those objects with detailed modelling .In the diagram, classes are represented with boxes which contain three parts The upper part holds the name of the class. The middle part contains the attributes of the class.

The bottom part gives the methods or operations the class can take or undertake

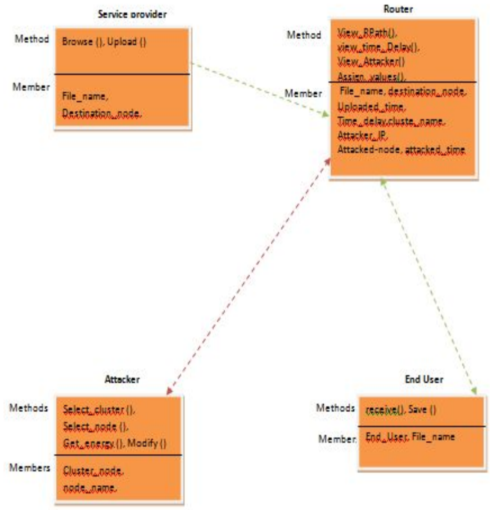

Fig: Class diagram

In the design of a system, a number of classes are identified and grouped together in a class diagram which helps to determine the static relations between those objects. With detailed modelling, the classes of the conceptual design are often split into a number of subclasses.

IMPLEMENTATION

6.1 Service provider: In this module, the service provider will browse the data file and then send to the particular receivers. Service provider will send their data file to router and router will connect to clusters, in a cluster highest energy sensor node will be activated and send to particular receiver (A, B, C…). And if any attacker will change the energy of the particular sensor node, then service provider will reassign the energy for sensor node.

6.2 Router:

The Router manages a multiple clusters to provide data storage service. In a router service provider can view the node details, view routing path, view time delay and view attackers. Router will accept the file from the service provider, the cluster head will select first and it size will reduced according to the file size, then next time when we send the file, the other node will be cluster head. Similarly, the cluster head will select different node based on highest energy. The time delay will be calculated based on the routing delay.

6.3 Cluster

In cluster n-number nodes are present and the clusters are communicates with every clusters. In a cluster the sensor node which have more energy considered as a cluster head. The service provider will assign the energy for each & every node. The service provider will upload the data file to the router; in a router clusters are activated and the cluster-based networks, to select the highest energy sensor nodes, and send to particular receivers.

6.4 Receiver (End User)

In this module, the receiver can receive the data file from the service provider via router. The receivers receive the file by without changing the File Contents. Users may receive particular data files within the network only.

6.5 Attacker

Attacker is one who is injecting the fake energy to the corresponding sensor nodes. The attacker decries the energy to the particular sensor node. After attacking the nodes, energy will be changed in a router.

CONCLUSION

In this paper. We used hybrid CS to design a clustering-based data collection method, to reduce the data transmissions in wireless sensor networks. Sensor nodes are organized into clusters. Within a cluster, data are collected to the cluster heads by shortest path routing; at the cluster head, data are compressed to the projections using the CS Technique. The projections are forwarded to the sink following a backbone tree. We first proposed an analytical model that studies the relationship between the size of clusters and number of transmissions in the hybrid CS method, to find the optimal size of clusters that can lead to Minimum number of transmissions. Then, we proposed a centralized clustering algorithm based on the results obtained from the analytical model. Finally, we present a distributed implementation of the clustering method. Extensive simulations confirm that our method can reduce the number of transmissions significantly. When the number of measurements is 10th of the number of nodes in the network, the simulation results show that our method can reduce the number of transmissions by about 60 percent compared with clustering method without using CS. Meanwhile, our method can reduce the number of transmissions up to 30 percent compared with the data collection method using SPT with the hybrid CS. Even for the nonhomogenous networks in the irregular sensor field, our method can significantly reduce data transmissions compared with these data collection methods.

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